A NOVEL METHOD TO SOLVE IMD-FSG PARTICLE AND INCREASE Cp YIELD BY USING A NEW TOUGHER UFUN SEASON FILM

FIELD OF THE INVENTION

The present invention relates generally to semiconductor fabrication and more specifically to processing chamber seasoning methods.

BACKGROUND OF THE INVENTION

Large particles falling from the reaction chamber's walls during FSG deposition results in tungsten (W) defects and reduces process capability (Cp) yield. These particles are FSG particles because of the outermost seasoning layer particles.

U.S. Patent No. 6,020,035 to Gupta et al. describes an undoped silicate glass (USG) seasoning film and process.

U.S. Patent No. 5,811,356 to Murugesh et al. describes a method and apparatus for reducing the concentration of mobile ion and metal contaminants in a processing chamber.

U.S. Patent No. 5,983,906 to Zhao et al. describes systems, methods and apparatus for depositing titanium films at rates of up to 200 Å/minute on semiconductor substrates from a titanium tetrachloride source.

U.S. Patent No. 6,121,161 to Rossman et al. describes a method and apparatus for controlling the introduction of contaminates into a deposition chamber that occur naturally within the chamber components.

U.S. Patent No. 6,136,211 to Qian et al. describes a self-cleaning etch process whereby during etching of a substrate in an etching chamber, a thin non-

homogeneous etch residue deposited on the surfaces of the walls and components of the etching chamber are simultaneously cleaned.

U.S. Patent No. 5,705,080 to Leung et al. describes a plasma-inert cover and plasma cleaning process.

SUMMARY OF THE INVENTION

Accordingly, it is an object of an embodiment of the present invention to provide an improved method of seasoning inner processing chamber walls.

Other objects will appear hereinafter.

It has now been discovered that the above and other objects of the present invention may be accomplished in the following manner. Specifically, a first USG film is formed over the processing chamber inner wall. An FSG film is formed over the first USG film. A second USG film is formed over the FSG film. A nitrogen-containing film is formed over the second USG film wherein the first USG film, the FSG film, the second USG film and the nitrogen-containing film comprise a UFUN season film.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which like reference numerals designate similar or corresponding elements, regions and portions and in which:

Figs. 1 to 5 schematically illustrate a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Unless otherwise specified, all structures, layers, steps, methods, etc. may be formed or accomplished by conventional steps or methods known in the prior art.

Problem Known to the Inventors

The following problem is known to the inventors and is not to be considered to be prior art for the purposes of this patent.

When using a standard seasoning film for an FSG deposition processing chamber, heating of the chamber while using a plasma radical such as Ar^+ in the presence of O^-, causes contaminating particles to drop onto the wafer within the chamber due to striking of the plasma ions against the standard seasoning film.

Initial Structure

As shown in Fig. 1, inner chamber wall 10 is a portion of a wall, or a component, of a processing chamber that may be used for FSG deposition commonly used to form inter metal dielectric (IMD) layers over a wafer within the chamber. Preferably inner chamber wall 10 is first cleaned using, for example,

preferably NF_3 as is known in the art to strip or remove substantially all traces of any previous seasoning film and any contaminants thereon or therein.

As shown in Fig. 1, a season-1 film 12 comprising undoped silicate glass (USG) is formed over the chamber wall 10 to a thickness of preferably from about 2400 to 2600Å, more preferably from about 2450 to 2550Å and most preferably about 2500Å at the following parameters:

<u>Season-1 Film 12</u>

about 20 seconds by time	Ar-side: about 95 sccm
turbo about 50 mT	Ar-top: about 15 sccm
about 3500 W RF, about 1W side-RF	O_2-side: about 270 sccm
0 W OFF	O_2-top: about 20 sccm
	SiH_4-side: about 180 sccm
	SiF_4: 0 sccm

<u>Formation of FSG Film 14</u>

As shown in Fig. 2, fluorinated silica glass (FSG) film 14 is then formed over season-1 USG film 12 to a thickness of preferably from about 650 to 750Å, more preferably from about 675 to 725Å and most preferably about 700Å at the following parameters:

FSG Film 14

about 3 seconds by time

turbo about 50 mT

about 3500 W RF, about 1W side-RF

0 W OFF

Ar-side: about 95 sccm

Ar-top: about 15 sccm

O_2-side: about 270 sccm

O_2-top: about 20 sccm

SiH_4-side: about 180 sccm

SiF_4: 5 sccm

Formation of Season-2 Film 16

As shown in Fig. 3, a season-2 film 16 comprising undoped silicate glass (USG) is formed over FSG film 14 to a thickness of preferably from about 2700 to 2900Å, more preferably from about 2750 to 2850Å and most preferably about 2800Å at the following parameters:

Season-2 Film 16

about 25 seconds by time

turbo about 50 mT

about 3500 W RF, about 1W side-RF

0 W OFF

Ar-side: about 95 sccm

Ar-top: about 15 sccm

O_2-side: about 270 sccm

O_2-top: about 20 sccm

SiH_4-side: about 180 sccm

SiF_4: 0 sccm

Formation of Film 18 - Key Step of the Invention

In a key step of the invention and as shown in Fig. 4, a nitrogen-containing film 18, preferably SiON or SiN and more preferably SiON, is then formed over Season-2 USG film 16 to a thickness of preferably from about 1300 to 1500Å, more preferably from about 1350 to 1450Å and most preferably about 1400Å at the following parameters:

SiON Film 18

about X seconds by time (with X being dependent upon the thickness of the SiON film 18 being formed)

turbo about 50 mT

about 3500 W RF, about 1W side-RF

0 W OFF

Ar-side: about 95 sccm

Ar-top: about 15 sccm

O_2-side: about 270 sccm

O_2-top: about 20 sccm

N_2: about 400 sccm

This completes formation of UFUN season film 20 comprising season-1 USG film 12/FSG film 14/season-2 USG film 16/SiON film 18.

As shown in Fig. 5, the inventors have discovered that SiON film 18 is resistant to plasma ion bombardment 22, e.g. Ar^+ ions, during, for example, heating of the chamber of which chamber wall 10 is a part. That is a greatly reduced amount of contaminating particles drop from the tougher SiON film 18 due to

plasma ion bombardment 22 during formation of, for example, an IMD-FSG layer over a wafer within the chamber.

For example the inventors have determined through KLA analyses:

FIRST ANALYSIS

Condition	STD			Oxynitride Surface		
Wafer ID	#20	#22	#24	#21	#23	#25
KLA Scan Total Data	33	278	304	21	475	113
FSG Particles	1	0	2	1	0	0

SECOND ANALYSIS

Condition	STD			Oxynitride Surface		
Wafer ID	#20	#22	#24	#21	#23	#25
KLA Scan Total Data	10	3	8	14	12	61
FSG Particles	1	1	1	1	0	0

This reduces defects in metal structures (for example tungsten (W) structures) over which the IMD-FSG layer is being formed and increases the

process capability (Cp) about 3%. This is because the nitrogen-containing film/SiON film 18 with Si - N bonding formation at the surface has a stronger bonding energy than Si - O bonding.

For example, the inventors have determined through experimentation using: a standard (STD) season film; an LDFSG film [while in deposition: side-RF = 3100W; top-RF = 720W; independent helium control (IHC) = 4.7/7.9 ; and deposition time (D/T) = 120 seconds]; and a UFUN film formed in accordance with the present invention [USG (20")/FSG (5")/USG (22")/SiON (10"); N_2 = 400 sccm; SiON (THK, center) = 1200Å; SiON (THK, edge) = 2400Å] with ΔF (STD) = 0.05 and ΔF (UFUN) = 0.08 that:

Film	Cp Yield Mean
STD	55.6
LDFSG	55.6
UFUN	59.7

In further examples using: a STD season film; and a UFUN film formed in accordance with the present invention [USG (20")/FSG (5")/USG (22")/SiON (5"); N_2 = 400 sccm; SiON (THK, center) = 1200Å; SiON (THK, edge) = 2400Å] with ΔF (STD) = 0.05 and ΔF (UFUN) = 0.08 that:

Film	Cp Yield Mean
STD	54.17
UFUN	58.24

and;

Film	Cp Yield Mean
STD	59.62
UFUN (SiON 4")	63.25
UFUN (SiON 7"	62.56

Yet further for burn-in lots:

Film	Cp Yield Mean
STD	59.44
UFUN (SiON 4")	62.31

Film	Cp Yield Mean
STD	69.85
UFUN (SiON 4")	74.00

Film	Cp Yield Mean
STD	68.25
UFUN (SiON 4")	67.59

wherein the related Bins short decrease from 12.9 to 11.7. Where Bins short is a particle related electrical analysis that indicates if the die is good or bad. The larger the Bins short within the wafer, the more bad dies there are.

The method of the present invention allows for three production runs within the chamber before cleaning/seasoning steps are required.

The inventors have found that Si-N bonding occurs at the surface of the UFUN film 20, i.e. the surface of nitrogen-containing film 18.

Further, the nitrogen-containing film 18 has a greater resistance to wet etching that the standard seasoning film and is therefore tougher. For example, the inventors have found:

Condition	Surface Wet Etch (E/R) (Å/second)
Standard Season Film	887
UFUN Season Film 20	640
Heated-up Standard Season Film	665
Heated-up UFUN Season Film 20	535

Advantages of the Present Invention

The advantages of the present invention include:

1. FSG particle contamination reduction; and
2. Cp yield improvement of about 3%.

While particular embodiments of the present invention have been illustrated and described, it is not intended to limit the invention, except as defined by the following claims.